INTRODUCTION TO TECHNICAL TOUR

The field trip schedule included a visit to three institutes at the Technical University of Denmark and to the industrial symbiosis in Kalundborg. Between the technical venues, the group visited the Viking ship museum in Roskilde, and after a very long day, the group relaxed over dinner in a picturesque but haunted old Danish castle.

Although in the homeland of the Vikings, astonishment at the means of transportation provided for the field trip

The NATO/CCMS group in life jackets going out to sea

And as the day passed the means of transportation got even quainter.

The NATO/CCMS Pilot Study group waving to the photographer

FIELD TRIP PRESENTATIONS

The Technical University of Denmark - DTU
As a modern technological university, DTU, the Technical University of Denmark, operates at a high international level in a wide array of activities in fields such as biotechnology, communications technology, nanotechnology and development of technologies for sustainable production and renewable energy. The University's research and teaching is provided by 32 institutes, a number of major independent centers established as joint ventures between DTU and companies and research institutes in the region. Like all modern universities, DTU also operates a number of transient and dynamic centers in which the driving force resides in collaboration across different fields of research and organizations.

DTU's physical presence in the north of Copenhagen gives it a natural part to play in fostering the Øresund region as a new "powerhouse" for research, the development of production facilities and educational provisions. The platform for this drive is made up of the region's 11 universities, 5 science parks and a heavy concentration of both old and new companies. For DTU, the most essential task is to secure and maintain the best possible framework for national and international cooperation in both State-funded and private research. This is the Alpha and Omega in the creation and communication of new knowledge for contributing sustainable added-value to society. The task is achieved in collaboration with R&D divisions in private companies, through patenting, the establishment of new enterprises and through the University's Bachelor and Masters courses, and training of new young researchers.

The University embraces most of the engineering disciplines, and trains engineers to Bachelor, Masters and PhD level. In addition, the University offers a comprehensive continuing education program, with a number of courses taught in English. The University has 6000 students preparing for Bachelor and Masters degrees, 600 PhD students and takes 400 foreign students per year on English-taught courses. DTU also has a permanent 400 of its Danish students away on varying length courses at foreign universities.

INSTITUTE PRESENTATIONS - TECHNICAL UNIVERSITY OF DENMARK

New technology for gasification of biomass.
Ulrik Henriksen, Biomass Gasification group

The Biomass Gasification group at ET, DTU have more than 15 years of experience within R&D and design of pyrolysis and gasification processes. The group is the Danish knowledge centre of biomass gasification. We are doing fundamental research, mathematical modelling and process design and optimisation. The two stage gasification process was developed here.

The two-stage gasification process
In the two-stage gasification process, the pyrolysis and the gasification process are separated into two different zones. In between the pyrolysis and the gasification zones, the volatiles from the pyrolysis are partially oxidised. Hereby, most of the tars are decomposed into harmless gas

molecules. To enable high energy efficiency, the thermal energy in the gasification gas and the exhaust gas is being used for drying, air preheating and for pyrolysis.
For small gasification plants (up to about 6 MW thermal), the traditional two-stage gasification process is well known. For larger gasification plants, a new way of integrating drying, pyrolysis, gasification and combustion unit is developed where the advantages of the traditional two-stage gasifier are maintained.

The most important advantages of the two-stage gasification process are:
- High gasifier and overall energy efficiency (above 90% cold gas efficiency).
- Low tar content in the produced gas (below 25 mg/Nm^3).The two-stage gasification process is a combination of well-known technologies.
- Uncomplicated gas cleaning system.
- Good process for fuels with high moisture content (up to 55% moist on wet basis).
- Low particle content in produced gas when the fuel has a high moisture content.
- Flexible choice of fuels (successful tests on straw, briquettes and woodchips).
- High temperatures limited to a minor, fully temperature controlled zone.
- Can be built in sizes of 0,5-100 MW (thermal input).
- Low emissions from thermal conversion unit and clean condensate when product gas is cooled.

Small-scale power production based on Stirling engines
Henrik Carlsen,

One of the activities in a large research and development program in Denmark concentrating on the development of decentralised combined heat and power (CHP) systems for biomass is the development of Stirling engines. The Stirling engine has external combustion, which makes it very attractive for this purpose.

Up to this point two different sizes of engines are considered. A Stirling engine designed for an electric power output of 35 kW has been built and tested using wood chips as fuel, and two 9 kW engines have been built and tested using natural gas and biogas as fuel.

After the 35 kW_{el} engine was tested in the laboratory for more than 600 hours it was mounted on a wood chip combustion system specially developed for this purpose. Currently this plant has run for more than 1400 hours using wood chips with very satisfactory results, and the field test is now continued. The plant is fully automated and it has been running unmanned most of the time.

Only minor problems with thermocouples and the wood chip feed have resulted in unplanned stops.

A new and improved 35 kW Stirling engine is now tested in the laboratory with natural gas as fuel. The test results so far has been very satisfactory, but a few changes have to be made. This engine is expected to be ready for field test in August 2000.

The 9 kW_{el} engines have been performing very well. They have been tested for more than 250 hours respectively, and they have showed, that they can produce a maximum output of 10.5 kW_{el}.

The Stirling engine development projects are funded by the Danish Energy Agency and it is carried out as a co-operation between Department of Energy Engineering, Technical University of Denmark, and several industrial companies.

ICEpower® - Switch-mode audio power amplifiers.
Associate Professor Michael Andersen

A research co-operation with the Danish audio/video manufacturer Bang & Olufsen has resulted in a break-through in amplifier technology. Project results shows that switch-mode (class D) techniques can now be used to realise high quality audio power amplifiers with an efficiency at full output power at ~94% and an energy efficiency in a normal user situation of ~30% (compared to a class B power amplifier with respectively ~60% and ~1%). This implies energy savings during operation of around 80%. The different parts of a switch-mode audio power amplifier with either an analogue or a digital input will be presented, and there will be focused on the techniques that has enabled these results. Moreover, there will be a short demonstration.

Low energy stand-by function
Associate Professor Michael Andersen and PhD Nils Nielsen

Stand-by lamps and power supply for electrical equipment uses a large part of the total electricity production world wide. This means, that even when the equipment is switched off, there is major electricity consumption. A solution to this problem has come closer with the development of a prototype stand-by power supply with losses as low as 0.025W-0.2W - a significant reduction when acknowledging that 3-5 W in e.g. televisions is considered low.

Newest developments in cleaner surface technology and micro technology.
Per Møller, Department of Manufacturing Engineering,

Materials technology and environment is becoming more and more integrated factors. In the future, material science will be the key for solving environmental problems in several industries. Therefore research in improvement of both process technology and products has to be an important area. The type of problems to be solved will be minimizing of material resources by

producing of products with improved lifetime by intelligent material selection and surface engineering, minimizing of the material consumption by miniaturizing of components (micro technology) and development of new processes and methods for reduction of waste and at the same time.

In this short introduction, some cases will be shown:

Case 1. Improvement of the efficiency for big power generators for power production by selecting of new materials for slip rings.

Case 2. Some examples of minimizing of material resources by application of micro technology.

Case 3. Design of a new multiflexible electroplating equipment for plating zinc and zinc/iron combined with 4 different conversion coatings, 3 different sealer systems and heat treatment to eliminate hydrogen embrittlement. The new equipment, with a capacity of 4000 metric ton/y is able to produce more than twenty useable combinations of zinc coating, conversion-coating and sealer. Furthermore the equipment is designed for waste minimization.

The cases show the philosophy behind the multidisciplinary way of thinking, when the goal is to obtain a holistic concept in the improvement of product quality and flexibility and at the same time reduce or eliminate the environmental problems. In many cases, there do not need to be a conflict between better quality and better environment .

INDUSTRY PRESENTATIONS

The Industrial Symbiosis at Kalundborg

Valdemar Christensen, Asnæs Power Station

In the industrial symbiosis of Kalundborg, several enterprises utilise each other's residual products in a network: Asnæs Power Station, Gyproc – a plasterboard manufacturer, the pharmaceutical and biotechnology group Novo Nordic, the Statoil Refinery, and the Municipality of Kalundborg. This mutual use of residues saves resources and reduces the burden on the environment significantly in an area with many heavy process industries. Moreover, it offers economic advantages to the parties involved, because all contracts within the symbiosis are based on commercial principles.

Asnæs Power Station

Valdemar Christensen, Asnæs Power Station

Asnæs Power Station is owned by SK Power, Denmark and is the country's largest power station, employing 500 people. The station is coal fired and covers about half of the demand for electricity on Zealand. Since 1980, Asnæs Power Station has supplied district heat to the town of Kalundborg and process steam to the Statoil Refinery and Novo Nordic.

Co-generation of heat and electricity means better fuel utilisation and cheaper heat than the customers can produce themselves, and the amount of heat wasted with the cooling water discharge to Kalundborg Fjord is reduced too. Some of the residual heat is used in a fish farm producing 200 tons of trout a year. The fish grow more rapidly in the warm cooling water. sludge from the fish farm's water treatment plant is used as fertiliser on nearby fields.
The desulphurisation unit at Asnæs Power Station, which has been in operation since the middle of 1993, produces about 100,000 tons of gypsum a year. The gypsum is sold to Gyproc, which makes plasterboard products for building industry.

Earlier, all water for steam production was ground water. Now water for steam has been replaced by surface water from Lake Tissø and by cooling water from the Statoil Refinery. The power station, then, returns some of the reused water to the refinery as steam.

The NATO/CCMS Pilot Study Group at Asnæs Power Station

Novo Nordisk
Anders Brinck Larsen, Novo Nordisk A/S

Novo Nordisk makes insulin and industrial enzymes. Its Kalundborg plant has about 1,200 employees. Novo Nordisk buys process steam from Asnæs Power Station and surface water from Lake Tissø. The company's enzyme production, which involves fermentatioon of raw materials such as potato flour and corn starch, produces large quantities of biomass containing nitrogen. the biomass is piped or transported by tanker to farms in West Zealand, where it is spread on the fields, replacing commercial fertiliser. Surplus yeast from the insulin production is now used as fodder. RETURN TO CONTENTS PAGE